



Terrestrial Planet Finder Mission

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Terrestrial Planet Finder

TPF EXPO'03

Dan Coulter, Project Manager

October 14, 2003



Why Are We Here?



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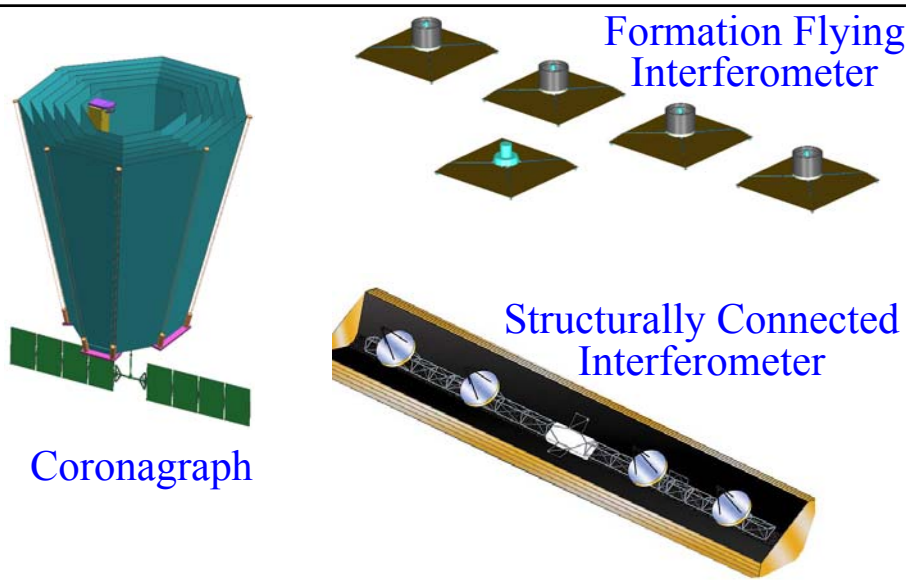
- From the Project's perspective the EXPO is a community engagement, outreach and communication opportunity
 - It brings together our science, engineering, technology and management community
 - It brings together our NASA, industry, academic and JPL stakeholders
 - We hope to provide you with useful information on the status of TPF over the next two and one half days
- From the community's perspective the EXPO is an opportunity to see, at least with broad brush strokes, what's going on with TPF
 - You will hear what we're doing all across the project (both inside and outside of JPL)
 - You will hear how well we're doing
 - You will hear about future plans
 - You will have an opportunity to network with the project and the rest of the community
- I invite you to comment on anything you hear or don't hear this week as well as whether you think this is a valuable use of two and one half days. Please email me at: **dcoulter@jpl.nasa.gov**



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Salient Features

- mid-IR nulling Interferometer (structurally connected or formation flying type) or visible-NIR Coronagraph
- Starlight suppression to 10^{-6} (mid-IR) or 10^{-10} (vis-nir)
- Launch Vehicle: EELV class
- L2 or Earth-trailing solar orbit
- 5 year mission life with 10 year goal
- Potential collaboration with European Space Agency DARWIN Mission

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Science

- Survey a *statistically significant number* of solar type stars for Earth-mass planets by suppressing the light of the parent star and looking for the faint reflected vis-nir light or the thermal emission in the mid-ir from planets in the “habitable zone”
- Make low resolution spectral observations of the brightest planets looking for evidence of a *habitable* planet using signatures such as O_2 , CO_2 and H_2O .
- Make very sensitive, low resolution spectral observations of the most interesting planets, looking for signposts of a planet that harbors life using potential biomarkers such as oxygen, ozone, or methane.
- Perform ancillary science as capability and time allow



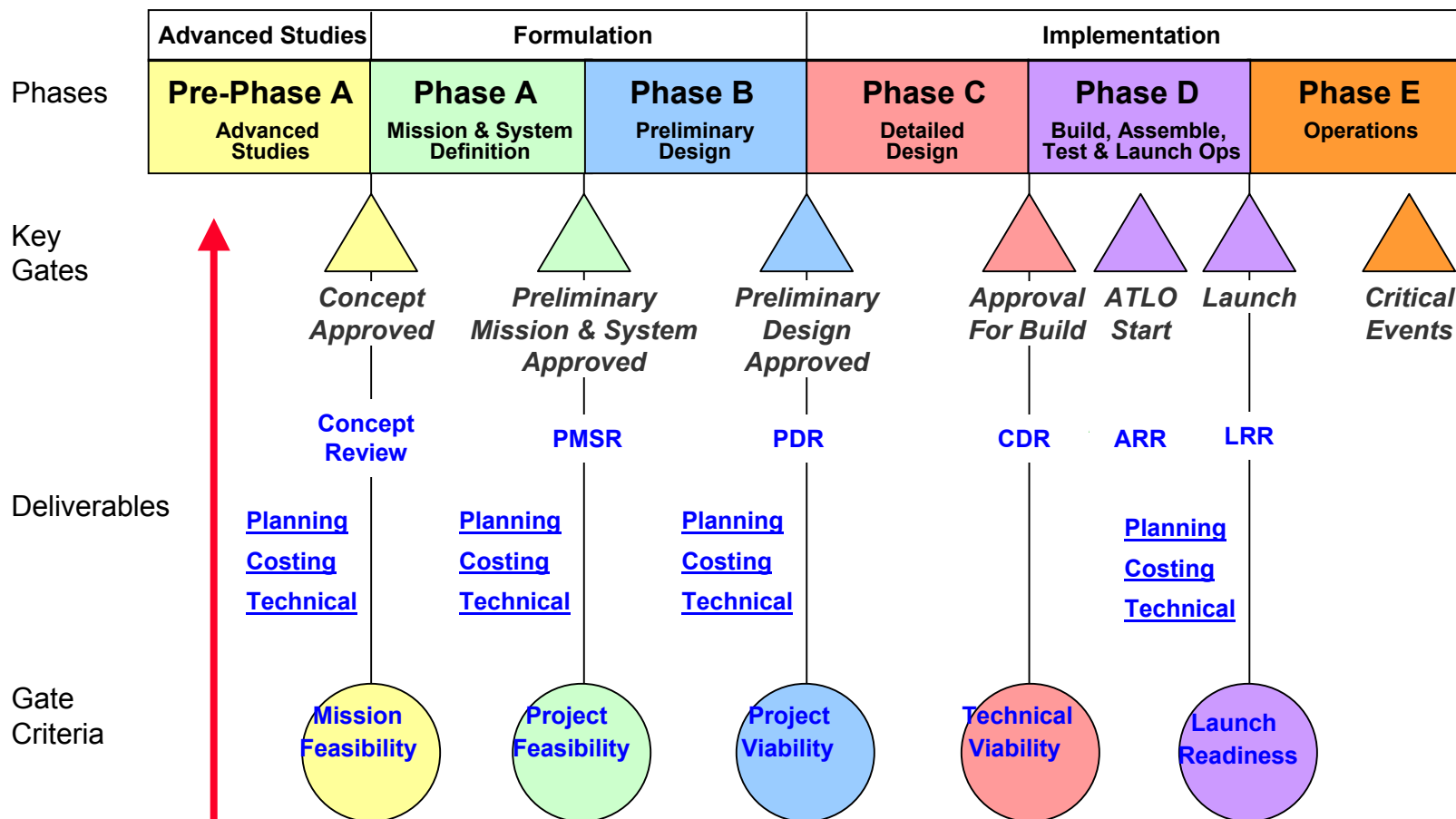
The NASA Project Life Cycle



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TPF is here- Major emphasis is on demonstrating mission feasibility through science, technology and architecture studies



TPF Success Criteria for the Pre-Phase A Period



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- Identify, characterize and document multiple feasible mission concepts capable of providing the TPF Science.
- Establish technical/engineering feasibility of *at least* one mission concept consistent with NASA's scientific, programmatic and cost goals-
be ready to enter Phase A in 2007
- Establish a robust precursor science program
- Meet or exceed the expectations of the TPF Stakeholders



What's Happened in the Last Year?



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- *The census of known exo-planets has increased to well over 100 including systems with multiple planets and systems beginning to look more like our own*
 - Numerous ground based searches are now in progress using several techniques with ever-improving sensitivity
 - Plans for planet finding space missions are proceeding (MOST, COROT, Kepler, Eddington, SIM)
- *We have greatly expanded the TPF community (academia, industry, GSFC, national observatories,...)*
 - Total spending in the academic and industrial community planned for FY04 is \approx \$20M
 - Academic and industrial partners now in excess of 100 (engineers, scientists, university faculty, graduate students, post-docs, managers...)
 - Increased from 7 external contracts to 40+ for science studies, design support and technology development (more still to come!)
 - Convened a new TPF Science Working Group with leading scientists
 - Including three ESA scientists
 - Established TPF Support Office at GSFC and incorporated GSFC scientists and engineers into the project
 - Staffed up at JPL from 21 FTE to 94 FTE



What's Happened in the Last Year?



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- *Developed new detailed pre-Phase A plan including merging with the Starlight Project*
 - Established new organization and WBS
 - Developed a detailed budget plan down to the individual task level for the pre-Phase A period covering the years FY03-FY06
 - Replanned twice to accommodate a \$10M cut in FY04 + \$7.1M “loan” to NASA for SIRTf in FY03
 - Established a goal to be ready to enter Phase A in FY2007
 - Expanded science studies and created a Precursor Science Roadmap
 - Added new TPF topic to the NASA Code S ROSS NRA
 - Established coronagraph and interferometer design teams and developed baseline instrument designs for candidate architectures
 - Expanded technology development and created a Technology Plan
- *Established regular interactions with the ESA DARWIN Project*
 - Co-sponsored first joint NASA/ESA Conference on the Search for Extra-Solar Planets (Heidelberg- May 2003)
- *Achieved good progress in key science, architecture and technology areas*



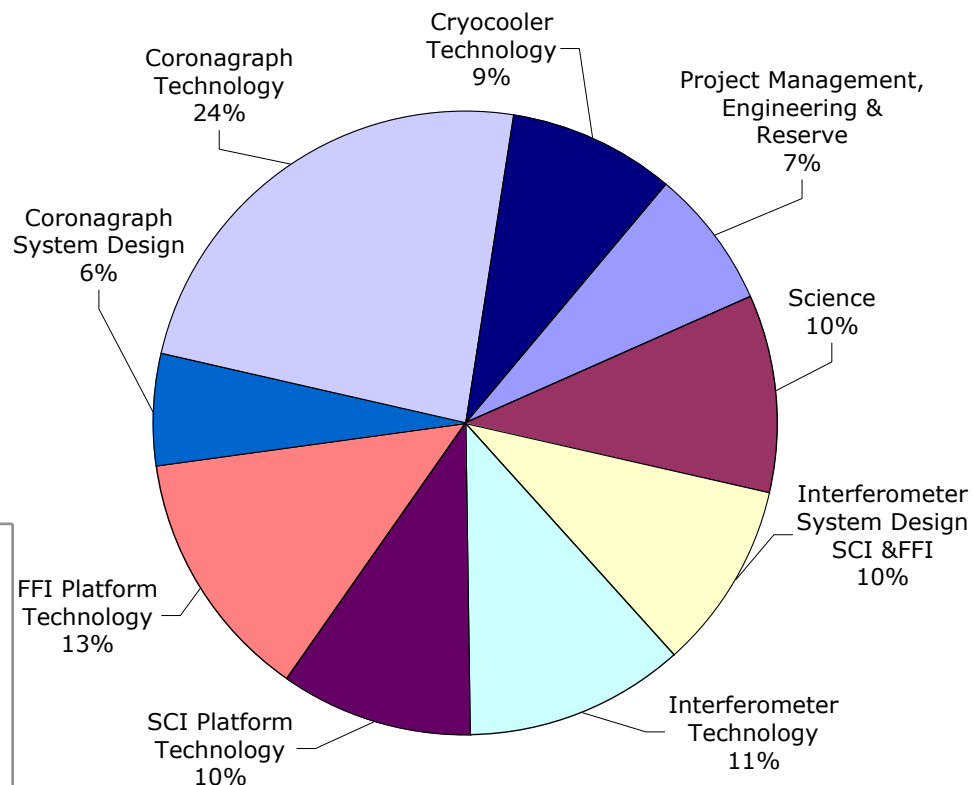
We Have a Balanced Plan



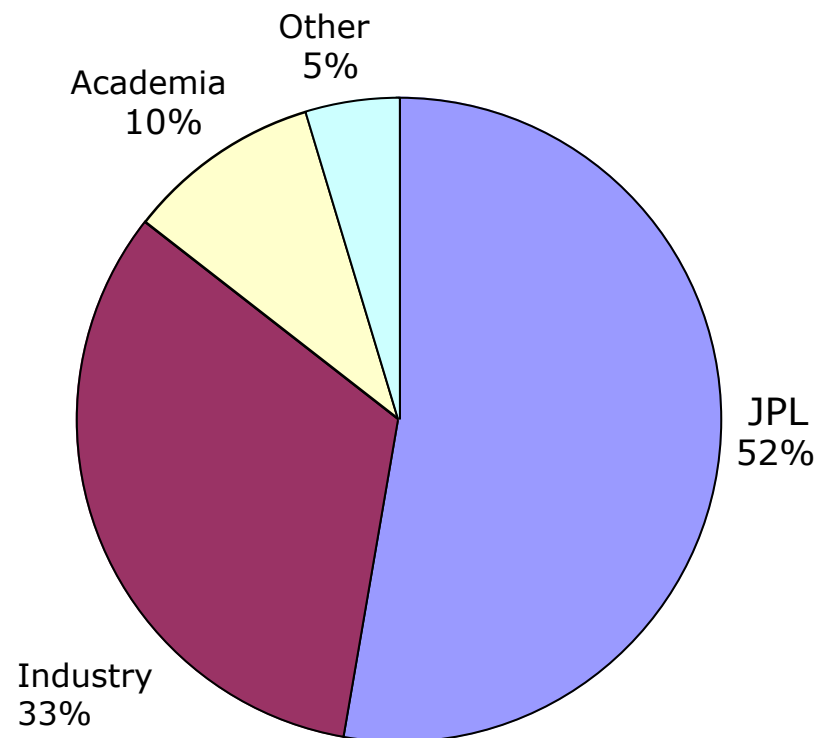
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Planned Spending By Major Element (FY03-FY06)



Planned Spending By Recipient (FY03-FY06)



2003 Architecture Studies



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- Two independent architecture study teams (Coronagraph, Interferometer) are analyzing various technical trades-offs with respect to TPF science requirements to identify multiple detailed point designs that could become viable mission concepts capable of delivering TPF science
- Both architecture study teams work closely with the TPF Science Working Group (SWG)
 - Teleconferences every two weeks or so
 - Technical Interchange Meetings (TIM) or SWG meetings every 3 months or so
- Both architecture study teams have a broad base of experience and expertise from participation by JPL, GSFC, the SWG, industry and academia
- Significant analysis and design progress has been made in FY'03
 - TPF Coronagraph baseline concept established
 - TPF Structurally Connected Interferometer concept (SCI) established
 - TPF Formation Flying Interferometer concept (FFI) established



2003 Technology Development



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- Three independent technology teams are implementing the Technology Plan developed by the TPF Project and approved by NASA
 - Interferometer Technology
 - Core, Structural Platform, Formation Flying Platform
 - Coronagraph Technology
 - Advanced Cryocooler Technology (Supporting multiple mission needs)
- The technology teams are coordinating with the architects, the design teams and the SWG to ensure effective flow of requirements and performance data
- The technology teams have a broad base of experience and expertise from participation by JPL, GSFC, academia, industry and the SWG
- Significant progress has been made in FY'03
 - Much more on this later
- A process has been developed for documenting, assessing and validating technology development information



2003 Science Activities



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- A new Science Working Group (SWG) was selected by NASA and came together for their first meeting in October 2002.
- The SWG is well balanced and includes experts in interferometry, coronagraphs and astrobiology as well as members with expertise in relevant areas of theory and observation
- Seven SWG Sub-Teams were created to focus on various aspects of TPF and provide a support and review function for the project
 - One additional subgroup is planned to focus on ancillary science capabilities for TPF
- The SWG has provided strong support to the project in FY03
 - Precursor science needs have been identified
 - “Working “ science requirements have been developed
 - The Coronagraph and Interferometer Sub-Teams have provided invaluable guidance to the design teams



How Well Are We Doing?

Technology Milestone Statistics



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KEY	
Complete (24)	
Partially Met (4)	
Not Met (4)	

FY2003 MILESTONES	Status	Update
Coronagraph Technology		
Technology Demonstration Mirror		
High Contrast Imaging Testbed (HCIT)		
Industry Coronagraph Technology		
Select technologies		
Release Solicitations		
Select contractors		
Apodized masks & Stops		
Fabricate initial masks		
Analysis of binary masks		
WFS & C		
Take delivery of 4096 actuator mirror		
Integrate into HCIT		
Tools for Integrated Modeling		
Structural/Optical alpha release		
Thermal module alpha release		
System test case modeled		
Advanced Nulling Technology		
Demonstrate visible nuller		
ACTDP		
Select Development Phase Contractors		
Hold Delta PDR's		

FY2003 MILESTONES	Status	Update
Interferometer Technology		
Core Technology		
Achromatic Nulling Testbed		
Narrowband nulling		
Broadband nulling		
Phasing System Testbed		
Definition		
Complete Development Breadboard		
Mid-IR Spatial Filters		
Advanced Nulling Technology		
Initial Integrated Optics Models		
Symmetric Beamsplitter Contract		
Cryogenic Delay Line		
Structurally Connected Platform		
SCIT- Study Phase Contracts		
Cryo-Structures Modeling & Technology		
Cryo/nano tests plan		
Preliminary Model Forms		
Formation Flying Platform		
FAST- real time, distributed, 2 S/C demo		
Formation Sensor Testbed		
Complete AFF		
Demonstrate Bearing Measurement		
FCT		
Formulation, architecture, design		
Robot #1 delivered		
SPHERES		

= Likely update to the Technology Plan



How Well Are We Doing?

Science and Architecture Study Milestone Statistics



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KEY	
Complete (12)	
Partially Met (4)	
Not Met (0)	

TPF FY2003 Architecture Milestones

Major Instrument Trades & Baseline Design Concepts	
"Small" Coronagraph	
"Large" Coronagraph	
Structurally Connected Interferometer	
Formation Flying Interferometer	

TPF FY2003 Science Milestones

Prepare TFP Science Roadmap	
Organize new SWG, Plan meetings and work efforts	
Support joint TPF/Darwin conference in Heidelberg	
Plan second joint conference (California, summer 2004)	
Support Major Science Meetings (AAS, etc)	
Science Working Group	
Develop "working" science requirements	
Identify supporting observation/theory efforts for Science Roadmap	
Develop Design Reference Mission(s)	
Support Interferometer Design team and review baseline designs	
Support Coronagraph Design team and review baseline designs	
Review and advise on Technology Roadmap	
Education & Public Outreach (Through the Navigator EP&O Office)	



New TPF SWG



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Name	Organization	Name	Organization
Dana Backman	Franklin & Marshall College	Vikki Meadows	JPL
Charles Beichman	JPL, Chair, TPF Project Scientist	Gary Melnick	Center for Astrophysics
Robert Brown	STScI	Bertrand Mennesson	JPL
Christopher Burrows	The Metajiva Cooperative	David W. Miller	MIT
William Danchi	GSFC	Charlie Noecker	Ball Aerospace
Alan Dressler	Carnegie Institution	Huub Rottgering	Leiden University
Malcolm Fridlund	ESA, Darwin Project Scientist	Sara Seager	Carnegie Institution
Eric Gaidos	University of Hawaii	Gene Serabyn	JPL
Phil Hinz	University of Arizona	William Sparks	STScI
Kenneth Johnston	US Naval Observatory	Wesley Traub	Center for Astrophysics
Marc Kuchner	Center for Astrophysics	John Trauger	JPL
Douglas Lin	UC Santa Cruz	Ted von Hippel	University of Texas
Rene Liseau	Stockholm Observatory	Neville Woolf	University of Arizona
Jonathan Lunine	University of Arizona		

Red = ESA Members



Coronagraph Background



Interferometer Background

- Held four SWG meetings
 - October 2002 (Pasadena)
 - December 2002 (Pasadena)
 - April 2003 (Pasadena)
 - September 2003 (US Naval Observatory)
- Held two Technical Interchange Meetings (TIMs)
 - Interferometer
 - July 2003 (JPL)
 - Coronagraph
 - August 2003 (JPL)
- Supported two ESA Terrestrial Exoplanet Science Advisory Team (TE-SAT) Meetings
 - May 2003 (ESTEC)
 - September 2003 (ESTEC)



NASA-ESA Interactions



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- Regular Monthly Management telecons
- Visit to ESA HQ in October 2003
- Joint annual science meetings
 - Heidelberg (2003)
 - Pasadena (2004)
- ESA Membership on TPF SWG
 - Malcolm Fridlund, Rene Liseau, Huub Rottgering
- NASA Membership on TE-SAT
 - Chas Beichman, Jonathan Lunine, Bill Danchi
- Coordination on Formation Flying Interferometer Architecture Studies
 - Evaluation of various formations
- Jointly participated in the International Symposium on Formation Flying Missions and Technology in Toulouse (October 2002)
- Coronagraph Workshop Planned in Leiden (February 2004)



TPF Schedule & Budget Assumptions

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- Schedule

- Complete pre-Phase A in early FY2007
 - Mission architecture feasibility demonstrated based on technology development and early precursor science (e.g. exo-zodi)
- Start Phase A in mid FY2007
 - Project feasibility and scope of the mission determined based on precursor science including improved knowledge of η_{earth} from ground studies, Kepler, COROT, Eddington,...
- Start Phase B/C/D when SIM launches
- Launch in mid next decade after JWST
 - Science targets based on SIM results

- Budget

- Current plan is based on the NASA POP 03-1 in-guide response
 - FY04 New Obligation Authority (NOA) is \approx \$40M
 - FY05/06 NOA is \approx \$50M/year
- In addition, the plan also assumes the following
 - The \$7M “loan” to SIRTf in FY03 will be repaid in early FY04
 - The \$10M cut in FY04 will be repaid in FY07



In Summary...



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- We are enabling Planet Finding Science
- We are growing a strong Planet Finding Community
- We have a good plan
- We have a balanced plan
 - Coronagraph, interferometer and cryocoolers
 - Science, technology and design
 - JPL and our partners
- We are making good progress
- We hope you are enthusiastic about being a part of the TPF Journey of Exploration and Discovery